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Abstract

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Nanomanipulation of Individual Carbon Nanotubes

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Carbon nanotubes have been found to have excellent electrical and mechanical properties [1]. Much work has been done to characterize the properties of individual nanotubes [2,3]. Traditional methods of characterizing nanotubes by lithographical metallization have are effective, yet arduous and expensive. In addition, these experiments are limited to so-called static characteristics of nanotubes, whether mechanical or electrical. Using a scanning electron microscope (Leo 1530VP FE-SEM) with a nanomanipulation system (Zyvex S100), multiwalled carbon nanotubes (MWNT) have been isolated and characterized *in situ*. The characterization of nanotubes with the S100 is dynamic in that the electrical properties as a function of mechanical strain can be uncovered.

The S100 is a joystick controlled, piezo-actuated, four-positioner, nanomanipulation system capable of in-vacuum and in-air operation. It has a resolution of less than five nanometers and a travel range of twelve millimeters. In addition to its manipulation capabilities, the S100 serves as a nano- and micro-scale probe station, for use in electrical characterization experiments involving currents from picoamps to microamps. Figure 1 shows the S100 head unit in an SEM. The probes shown are electrochemically etched tungsten wires that have a radius of curvature on the order of tens of nanometers. The tungsten probes are coated with palladium to help assure an ohmic contact to the carbon nanotube. MWNT powder was stuck to one side of conducting carbon tape. A small piece of silicon was cleaved such that the edge formed a sharp taper. This edge was scraped across clean carbon tape and then scraped across the stuck down nanotubes. The result is a sharp surface edge with nanotubes protruding outwardly. This procedure allows for relatively easy manipulation of individual nanotubes.

A MWNT was extracted from the surface as shown in Figure 2a. A process known as electron bean induced deposition (EBID, also known as contamination writing) was used to locally “weld” the nanotube to the probe. Once the nanotube is affixed at one end, a second probe is brought in and attached in a similar manner (Figure 2b). Current-voltage (IV) measurements are made by performing a voltage sweep with test electronics (Keithley SCS-4200). Figure 3 shows the preliminary data collected on this particular nanotube.

Our results demonstrate the feasibility of *in situ* manipulation and characterization of individual carbon nanotubes.

References

[1] R. H. Baughman, A.A. Zakhidov and W.A. de Heer, *Science* 297 (2002), 787.
[2] P. G. Collins, M.S. Arnold and Ph. Avouris, *Science* 292, (2001), 706.
[3] M-F Yu, O. Lourie, M.J. Dyer, K. Moloni, T.F. Kelly and R.S. Ruoff, *Science*, 287, (2000), 637.

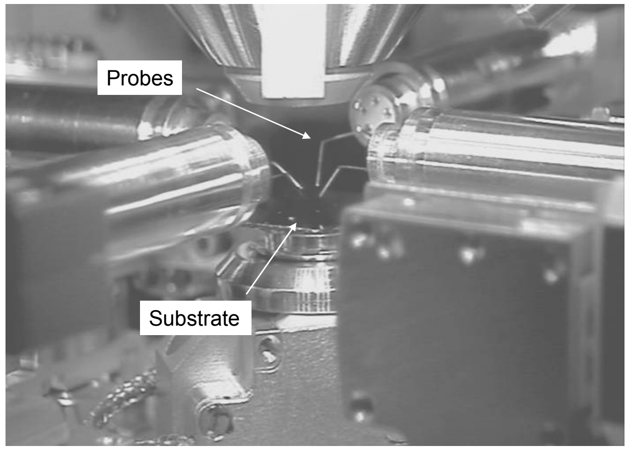

FIG. 1. The Zyvex S100 Nanomanipulator in the Leo 1530VP SEM. The arrows indicate the probes and the substrate.

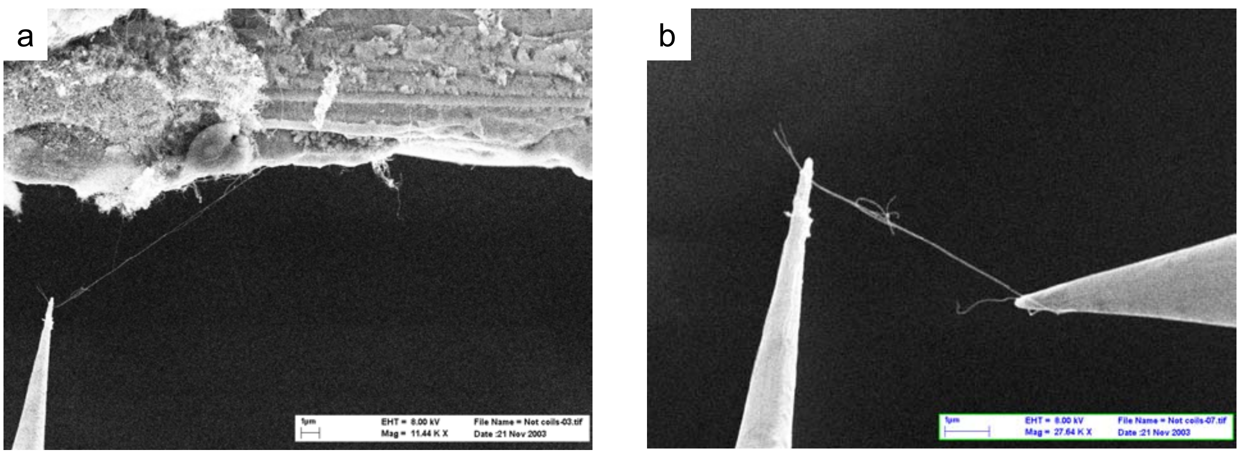

FIG. 2. Scanning electron micrographs of pulling a nanotube from a surface (a) and affixing each end to a probe (b). The probes are palladium-coated etched tungsten wires.

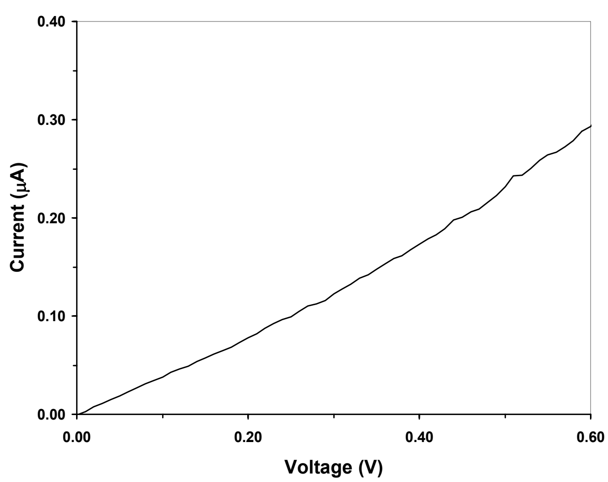

FIG. 3. Preliminary two-probe IV curve of a multiwalled carbon nanotube.